

Before the
Federal Communications Commission
Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of:

Amendment of the Commission's Rules to
Establish Part 27, the Wireless
Communications Service ("WCS")

GN Docket No. 96-228

Comments of Motorola DOCKET FILE COPY ORIGINAL

Motorola Inc. (hereinafter Motorola) submits these comments in the above-captioned proceeding.

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I. Summary

At 2.3 GHz, the Appropriations Act directs the Commission to assign licenses by auctions beginning no later than April 15, 1997 and to deposit all funds in the U.S. Treasury by September 30, 1997. The Commission's follow-up Notice of Proposed Rulemaking proposes to let each auction winner determine how the spectrum is used instead of allocating the spectrum to a well defined service.

Motorola is concerned that these approaches being used to provide for the utilization of spectrum at 2.3 GHz hold grave consequences for the U.S. telecommunications industry, particularly if Congress and the Commission perceive such an approach to be a precedent for spectrum management reform. In particular, deficit reduction rather than market requirements appear to have driven the Congressional mandates for release of this spectrum. Spectrum is too valuable a communications resource to be treated as a convenient way of meeting the Federal budget requirements. Wireless telecommunications, and the many civil societal needs it fills, contribute far too much to the U.S. economy and quality of life to be managed solely on this basis.

We understand that the Commission faces some constraints based on Congressional direction in the instant proceeding. However, the Commission's 2.3 GHz proposal to allow license auction winners to provide any fixed, mobile, radiolocation or satellite digital audio radio service throughout the band could unintentionally fracture the market, raise equipment costs to users, retard manufacturer investment, increase interference and threaten the investment of existing operators. Such results are simply not compatible with sound spectrum management.

Even if Congressional direction on this particular band is irreversible, the Commission should at least focus on a more defined set of services at 2.3 GHz, using band segmentation if necessary to achieve compatibility among disparate service offerings. Further, in discharging its duty as an expert spectrum manager, we respectfully suggest that the Commission be more aggressive in recommending that spectrum policy decisions place a higher priority on market requirements rather than on deficit reduction.

As an alternative, Motorola recommends the Commission define a specific allocation for the bands. For example, a portion of the band could be dedicated to public safety fixed point-to-point operation if auctions are not required over the entire band.

II. The Approach Being Used to Manage Spectrum Utilization at 2.3 GHz Portend Serious Damage to Broad U.S. Interests

The Appropriations Act directs the Commission to allocate the 2305-2320/2345-2360 MHz band, to assign licenses by auctions beginning no later than April 15, 1997 and to deposit all funds in the U.S. Treasury by September 30, 1997. This is a departure from previous Congressional authority, which requires that the particular use of spectrum be decided before committing to auctions as a license assignment tool.¹ Furthermore, the Commission's NPRM in this proceeding proposes to allow auction winners essentially to determine how the spectrum will be allocated. Under the proposal, each licensee would have full flexibility to offer any fixed, mobile, radiolocation or satellite digital audio radio service.

Motorola is concerned that this spectrum management approach could unintentionally bring serious damage to the U.S. telecommunications industry. The direction set forth by Congress and the rules proposed by the Commission at 2.3 GHz hold a high risk of fracturing the market, thereby retarding investment in systems both by operators and manufacturers. At best, this revenue driven approach is an isolated departure from a successful formula. At worst, it signals a disturbing trend in U.S. spectrum management likely to yield an unsuccessful track record which is atypical of the telecommunications industry. Left unabated, such a trend could affect the U.S. telecommunications industry's stature in both the domestic and global markets. Just as past success has increased employment, future failure can reduce it.

The wireless telecommunications industry has been extremely successful in the United States. Today, a vibrant U. S. market supports approximately 90 million cellular phones, pagers and dispatch radios. Underlying these volume markets is the safety, utility and convenience wireless telecommunications bring to consumers and workers. People are no longer tied to their home or office locations as a requirement to communicate by phone. Parents can be paged if needed while away from home. Dispatch radio provides a critical tool necessary for police, fire and emergency medical personnel, as well as utilities,

¹ Section 309 of the Communications Act limits the Commission's use of auctions as a tool to resolve mutually exclusive license applications for subscriber based services.

construction firms, and both large and small businesses. Travelers can phone from their seat on an airplane. In addition, U.S. consumers use a number of other possibly less apparent wireless products every day. For example, cordless phones, remote control garage door openers, and remote auto door locks are all devices which have been unobtrusively integrated into our day-to-day routines.

Sound spectrum management was a key element in the successful development and implementation of all these products and services. Thoughtful spectrum management actions formed the basis upon which companies made decisions regarding investment in technology development and volume manufacturing facilities. These investments gave birth to new products, reduced equipment cost and size and increased quality and features. In turn, operators have access to such products which help drive the demand for services. As a result, the U.S. consumer today has a broad range of products and services available to fill its communications needs. Without these thoughtful spectrum management decisions, generally based on a rational balancing of competing interests, and the investment they encouraged, the U.S. would be a significantly less safe, less prosperous and less enjoyable country in which to live.

All of the successful services noted above were implemented prior to the recent focus on auctions as a license assignment tool and deficit reduction resource. More recently, a number of narrowband and broadband PCS licenses which were auctioned are now being built out and hold the promise to be successful as well.² It is important to remember, however, that the spectrum allocation, service and technical rules for these PCS services had been debated and were largely designed in the absence of auction authority. This allowed the Commission to optimize its decisions based on market needs rather than focus on deficit reduction as the priority during the decision making process. In contrast, the direction in the Congressional Appropriations Act and the follow-up FCC NPRM for 2.3 GHz appear to place a higher priority on quick revenue for the U.S. Treasury than on market requirements and sound spectrum management.

² Success in raising short-term revenue for the government in the PCS auctions is not synonymous with the longer term success of these services. Those licensees who submitted bids based on valid business plans are more likely to be successful. Those licensees who felt pressured to bid higher as a necessary condition to gain access to the spectrum or otherwise be left out may find it difficult to recoup that investment with a reasonable profit, i.e., the winner's curse. The ultimate failure of any PCS licensee of course could yield substantial costs for the public and the government in lost jobs, investment, service and longer term tax revenues.

Auctions in and of themselves can be an effective license assignment tool for certain services if applied properly. Unfortunately, the revenue generated thus far by auctions appears to be a temptation so great that it causes policy makers to misapply this tool. Using auctions as a substitute for sound spectrum allocation decisions, as proposed in this proceeding, is one example of policy dictated by one interest -- short term revenue needs -- driving out rational public policy decision making. Another example, which has been used in other bands, is implementation of freezes on legitimate applications in existing services. In anticipation of overlay auctions, such freezes have already been implemented in the 900 MHz paging and the 800 MHz general category dispatch channels. Further, grants of properly filed applications in the 900 MHz private business pool are being delayed with no explanation, raising concerns that a freeze and overlay auctions are being planned there as well. These overextensions of auctions and related actions cause undue burdens on the industry, especially by increasing uncertainty and mistrust of the Commission's motives.

The timetables in the Appropriations Act appear to be driven by the desire to count any auction revenues in the Government's 1997 fiscal year budget, rather than any pressing need to release the 2.3 GHz band for subscriber based services. This is particularly disturbing as successful implementation of any wireless application in this band begins with investment in underlying technology R&D based on projections of potential market requirements. These longer-term investment decisions become completely chaotic, wasteful and ineffective in meeting customer needs if spectrum release in any given band is driven by Federal budget considerations rather than market need.

Further, this unusually fast schedule for deploying the spectrum and scoring the revenue has clearly impacted any serious consideration on how the spectrum should be allocated and how the rules could best be structured for such an allocation. For example, the Commission's NPRM proposes to allocate the spectrum for a non-descript "Wireless Communications Service (WCS)" in which each licensee would have complete freedom to offer any mobile, fixed, radiolocation or digital audio radio satellite service. In essence, such an approach avoids making a real allocation decision as each auction winner could legally provide whatever service he or she wants. While we agree that some degree of freedom and flexibility are desirable, Motorola is very concerned that a total laissez-faire approach is not in the best interest of telecommunications manufacturers, providers or users.

Consider the potential results of the proposal at 2.3 GHz. License auction winners in the top ten markets could each decide to offer a different service requiring substantially distinct equipment. Thus, for example, the New York licensee could offer radiolocation, while the Los Angeles licensee offers mobile data and the Chicago licensee offers fixed backhaul and so on.

From a potential operator's perspective, a significant problem exists right at the outset. Defining a target service tends to attract knowledgeable bidding participants who can properly "value" the service and their spectrum bids. With no defined service, a wide variety of entrepreneurial participants bid against each other for undefined uses of the spectrum. Rational bidding strategies are extremely difficult if not impossible and bidders therefore face a very high risk of substantially under-valuing or over-valuing the spectrum. Also, full flexibility is not a panacea for individual operators as their success can be significantly impacted by an investment community averse to the high risks that this scenario imposes.

From a manufacturer's perspective, pending agreement with a particular auction winner there is no momentum for product development as the Commission has failed to make any real allocation decisions in consultation with the users, providers and manufacturers. Equipment manufacturers would face complete uncertainty until auction winners are chosen, they announce how the spectrum is to be used and individual manufacturer/operator negotiations are concluded. As a result, investment in product development can no longer proceed on a planned basis as allocation decisions are made by individual licensees rather than any market-wide momentum.

In addition, the proposed Commission approach fractures the market that ultimately exists. Even if manufacturers decide to take the significant risk to invest in product development on an operator-by-operator basis, equipment costs would be higher as the volume needed to drive down cost would be non-existent. There is no free lunch. The consumer ultimately pays for these higher costs either directly or through higher service fees when equipment costs are subsidized by operators.

This method of "spectrum management" has other potentially grave consequences as well. It is not at all clear how the Commission hopes to minimize interference under its proposal to mix any and all fixed, mobile, radiolocation and satellite digital audio radio services throughout the bands. Optimizing each of these services for success requires a

given set of infrastructure implementation, equipment powers, receiver performance and a myriad of other technical parameters. Given the wide range of these parameters, perfectly legal transmitters for a given application could cause harmful interference to the receivers of another. Out of the gate, operators face increased risks of interference compared to alternative approaches which consider the viability of successful coexistence among defined services. All services would be co-primary, so all licensees would have the same rights. Significant Commission involvement to resolve disputes is inevitable under such a chaotic approach.

Furthermore, operators who have won license auctions may find their investments de-valued as the U.S. drives spectrum allocations based on deficit reduction rather than market need. Congressional and Commission economists should consider the potential impact of placing clear spectrum on the street for subscriber-based services so soon after licensees have paid substantial sums of money into the U.S. treasury. If such actions become the norm, it would be entirely prudent for potential bidders to be much more cautious in their good faith bidding.

Finally, we note that the Commission previously experimented with an undefined allocation which ultimately brought no benefit to the public. In 1986, the Commission allocated 2 MHz of spectrum at 901-902 and 940-941 MHz to a "General Purpose Mobile Service."³ Reviewing the decision shows that it was based in large part on the Commission's desire to experiment. There was no public outcry for such an allocation and a number of industry representatives warned against such undefined experiments. Service rules were never developed as there was insufficient interest in the allocation to encourage its pursuit.

The public benefited only when that spectrum was reallocated almost seven years later for narrowband PCS in response to industry interest in the bands for advanced messaging and paging services. Interest in the band for these services provided a framework within which to focus technical and service rules responsive to market needs. The Commission also incorporated significant flexibility for manufacturers and operators to provide innovative products and services. In this allocation, the Commission was able to

³ Report and Order in GEN Dockets 84-1231, 84-1233 and 84-1234 at page 44, released September 26, 1986.

provide a requisite balance of flexibility and certainty which does not appear to be evident in the Congressionally driven proposal at 2.3 GHz.

In summary, Motorola believes the approach being used at 2.3 GHz is not in the best interest of consumers, manufacturers or operators. This is of even greater concern if Congress and the Commission perceive such an approach to be a precedent for spectrum management reform. There appears to be little doubt that the impetus to release this spectrum and require subscriber based license auctions is based primarily on short-term Federal budget considerations. Further, fractured operator-by-operator allocation decisions as proposed by the Commission substantially increase the risk that deployment in this spectrum will be unsuccessful.

III. Consideration of Public Safety Needs

In the Appropriations Act, Congress also directed the Commission to consider public safety needs in designing the auctions for the 2.3 GHz band. Understandably, the Commission has requested comment on how it should consider public safety requirements in this band. The basic direction to auction licenses, however, would appear to constitute an inherent legal conflict as such auctions would not be allowed for public safety services under the Commission's competitive bidding authority.

Even if allowed legally, auctions appear to hold little promise for public safety spectrum relief. Given the history of spectrum auction bidding, it is extremely unlikely that public safety entities could successfully compete against commercial providers in a license auction. Relying on a commercial provider as an alternative would leave control of critical communications systems to a third party. It is not clear that public safety entities would view such an arrangement as appropriate, given the high degree of reliability and operational control they require. Furthermore, as discussed in the previous section, the non-specific service allocation approach envisioned here for auction by the Commission, leaves public safety entities with no information on what these ultimate services will be or what degree of interference systems may experience.

As pointed out in the NPRM, the 2.3 GHz band is not included in the Public Safety Wireless Advisory Committee recommendations as a resource to solve public safety spectrum requirements.⁴ Instead, PSWAC recommended the following:

In the short term (within 5 years), approximately 25 MHz of new Public Safety allocations are needed. The present shortages can be addressed by making part of the spectrum presently used for television broadcast channels 60-69 available as soon as possible.⁵

Motorola notes that spectrum in channels 60-69 (746-806 MHz) is much better suited to the wide area communications requirement of public safety entities. Compared to 2.3 GHz this spectrum would save public safety entities substantial costs on infrastructure deployment. As addressed below and in Appendix A, the cost disparity between the 800 MHz and 2.3 GHz bands is far greater than one would naturally assume based on the relative band positions alone.

Unlike commercial subscriber-based services, many public safety entities must plan systems to provide peak capacity requirements anywhere within the core metropolitan area. Emergency incidents requiring a full complement of public safety services are not planned, they can happen anywhere. At lower frequency bands, this is relatively straight forward, as one site may cover an entire jurisdiction. The system's peak capacity is available anywhere covered by that site. As one moves higher in the bands, e.g., to 2.3 GHz, propagation conditions may require a multitude of antenna sites to provide the requisite degree of coverage and reliability. As the system must be planned to handle disasters throughout the core metropolitan area, essentially every system site must have the capability to provide peak capacity. The infrastructure cost differential then is the added cost of providing full capacity at all sites, rather than the mere difference in the cost of one base station at 2.3 GHz compared to that at 800 MHz. As shown in Appendix A, this cost differential can be substantial, e.g., a factor of 17 times greater in core metropolitan areas where spectrum congestion is of greatest concern.

⁴ PSWAC Final Report dated September 11, 1996, submitted to the Commission in Docket 96-86.

⁵ PSWAC Final Report at page 3.

Also, 800 MHz spectrum such as that in TV channels 60-69 has the added advantage of close proximity to existing 800 MHz public safety bands. This close proximity establishes the basis for a much greater degree of interoperability among public safety users, a key concern in the PSWAC deliberations. In contrast, 2.3 GHz would be far removed from any existing mobile public safety allocation.

Even if the Commission had the authority to allocate the entire 30 MHz at 2.3 GHz to public safety with no auctions, users' costs would be substantially greater and the possibility of interoperability lessened compared to that at 800 MHz. In any case, changes in Congressional direction for this band would appear to be necessary to accomplish that degree of consideration for public safety.

Fortunately, solutions which can provide public safety both substantially lower costs than that at 2.3 GHz and improved interoperability are possible. The Commission can recover spectrum in TV channels 60-69 so it can be allocated to meet public safety mobile system needs. Recently, Motorola filed extensive analysis and recommendations in a separate Commission proceeding proposing a draft DTV allotment plan. In that proceeding, the Commission proposed long-term recovery of spectrum in TV channels 2-6 and 52-59, with nearer term recovery of spectrum in TV channels 60-69. The Commission's proposed draft allotment plan limited new assignments in channels 60-69 to aid in recovery of that spectrum. Motorola's comments in that proceeding provided substantive recommendations and specific changes to the draft allotment plan. These changes and recommendations would allow faster and more meaningful spectrum recovery, to assist the Commission in responding to PSWAC's demonstrated mobile spectrum requirements and recommended solutions. Using Motorola's recommendations, the Commission can establish viable solutions for both the public safety and broadcast communities.

We note that the PSWAC report also references requirements for additional fixed point-to-point spectrum. Private microwave licensees including public safety users are vacating the 1.8 GHz microwave bands to make way for PCS system deployment. In addition, spectrum in the 2.1-2.2 GHz band now used for point-to-point microwave has been identified for redevelopment and segments of those bands have been proposed for mobile satellite operation. Given the close proximity of the 2.3 GHz spectrum under

consideration in this docket, it may be advisable to consider dedicating a portion of the band for public safety fixed use.

Current equipment at 2.2 GHz uses 800 kHz channels. Therefore, as an example, the Commission could allocate 16 MHz (8+8 MHz paired) of this band for public safety fixed point-to-point operations, which would provide 10 paired channels for use in a frequency coordinated manner. Practically, auctions would be unnecessary as a license assignment tool because point-to-point systems can normally be engineered in to eliminate any mutual exclusivity. This is one possibility; the Commission should look to the public safety community for definitive recommendations on how best to use this spectrum to help meet its needs. The Commission should also seek guidance from Congress whether the Appropriations Act would allow 2.3 GHz band public safety licenses to be granted without an auction.

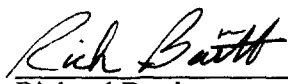
III. Conclusion


The combination of Congressional direction and Commission proposals for the 2.3 GHz band could unintentionally fracture the market, raise equipment costs to users, retard manufacturer investment, increase interference and threaten the investment of existing operators. Such results are simply not compatible with sound spectrum management. Motorola is particularly concerned if the approach being used at 2.3 GHz is viewed by Congress and/or the Commission as a blueprint for spectrum reform. Spectrum is too valuable a communications resource to be treated only as a convenient way of meeting the Federal budget requirements. Wireless telecommunications, and the many civil societal needs it fills, contribute far too much to the U.S. economy and quality of life to be managed solely on this basis.

Motorola does not believe the 2.3 GHz band holds significant promise to solve public safety mobile communications needs. As addressed herein, infrastructure providing the capacity, coverage and reliability which public safety users require would be much more expensive than that at lower bands. Recovery of TV channels 60-69 as recommended in the PSWAC report provides a much better alternative to meet public safety mobile spectrum requirements. Spectrum in the 2.3 GHz band could, however, be appropriate to help provide public safety users fixed point-to-point capacity if the Commission can obtain Congressional clarification that auctions would not be required for that portion of the band.

Respectfully Submitted,

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APPENDIX A

SPECTRUM "COST" vs. FREQUENCY PUBLIC SAFETY 2300 MHz CONSIDERATIONS

Abstract

An examination is made of the issues, system costs and complexities for wide-area communications systems, as a function of increased operating frequency band. Technical relationships are developed, with significant differences between Public Safety and public cellular telephone applications noted. A conclusion is reached that the cost/complexity to implement a comparable wide-area, portable communication system, with in-building coverage at 2300 MHz vs. 850 MHz is about 17:1.

Introduction

PSWAC has concluded a need for 95.3 MHz additional spectrum within the next 15 years, with 25 MHz needed "immediately" i.e. by the year 2000. PSWAC also recommends spectral areas to focus on in satisfying these needs, including VHF, UHF, 800/900 MHz and 1.7 GHz⁶.

It is obvious that there is a difference in "spectral quality" or degree of appropriateness of various frequency bands in-so-far as their use for envisioned applications. For example, one does not have to reach too far to understand that a given amount of 450 MHz spectrum would be more suited to and thus more valuable to a wide area urban coverage requirement than would be the same amount of spectrum at, say, 28 GHz or 30 MHz.

Moreover, it would be expected that the optimum frequency band would vary as a function of the application, for instance wide-area portable, on-site in-building, point-to-point, satellite, etc. It is demonstrated in the PSWAC report that, when considering all of the various and related factors of propagation loss, antenna gains, building penetration losses, etc., that about 850 MHz tends to be optimum for urban coverage situations with in-building requirements.

It is therefore incorrect to believe that spectrum at a certain frequency will satisfy an application need just as well as at some other frequency, for there is an implied "cost function" associated with the use of various spectra for the given application and these costs must be considered in the evaluation of various alternatives.

Considerations

A key cost value parameter associated with spectrum use is coverage area for a given transmitter power level, as subsequently adjusted by allowed maximum power level (as might be determined by such as FCC use rules, ME (lector-magnetic exposure) restrictions, technology limitations, etc.). "Coverage cost" can be used in valuing various spectrum alternatives and, assuming an

⁶ 2.3GHz spectrum was not available for consideration during PSWAC studies.

optimum spectral frequency f_o has a reference "cost" of 1.0, other spectrum alternatives will carry associated cost factors. These costs will be, in general, proportional to the ratio of the number of new cells required to provide the same coverage, with similar performance, as the reference cell assumption.

Consider that a given amount of "optimum" spectrum (N channels) in a single cell coverage area is just sufficient to support the capacity requirements (for a given per user peaking demand with corresponding communications quality level). Since cell radius is generally defined by unlink limitations, let it be assumed that the portable devices use maximum allowed transmitter power and that the power is limited by ME requirements at that frequency. Finally, the base station antenna occupies the prime "high ground" in the area.

If the reference system operating frequency is substantially increased, reduced coverage area results, all other things constant. Without increasing portable transmitter power, the only way to recover to the original coverage area is to add additional cells, with associated increased costs.

Though it may be tempting to think that, for instance, four cells, each of $1/4$ the area and using all the same N channels can replace the one, this is not specifically the case, considering cell-to-cell interference⁷. If the average user capacity demand is uniform across the total area, then no additional spectrum is required, as each cell can be assigned $1/4$ of the channels, with no frequency reuse, to serve the $1/4$ of the total users in each cell. This cell dividing process can continue until the point where each of the many cells uses just one of the available channels, at which point additional cells can be created using appropriate frequency reuse patterns.

In a public telephone type system where the peak-to-average service demand remains relatively constant, independent of cell size, each cell is provisioned with $1/4$ the equipment of the single cell e.g. transmitters, receivers, antennas, combines, back-up power, floor space, etc. This tends to hold down the net cost increase as cell count increases.⁸

However, for a system with a high peak local demand requirement somewhere in the coverage area, but unknown where beforehand, the above simple approach does not work. This is the case for most Public Safety systems, as well as many services that have significant emergency preparedness responsibilities (e.g. electric utilities).

Consider in this case that if in the single reference cell, $N/2$ channels represent average use, that a peak capability of another $N/2$ channels exists to be brought to bear in any emergency anywhere in the total coverage area.⁹ In reality, even

⁷ Two adjacent cells using the same frequencies would render each unusable due to co-channel interference. This can sometimes be worked around with "simulcast" approaches where specific geographical features intervene between the two cells.

⁸ The cost is, however, certainly not constant in that additional expenditures are incurred for equipment/antenna site leases, tower costs, etc.

⁹ It is assumed that the reference cell is fully equipped for simultaneous operation on all N channels.

greater than $N/2$ additional channels may be used in the local area emergency (in the limit, up to N), given that some of the “average” users migrate to that location, reducing channel demand in the rest of the geographical area.¹⁰

Consider that the typical public system implementation approach is taken in response to a requirement to use much higher allocated frequencies; again for example, four smaller cells are created, each with $N/4$ channels available. It is immediately obvious that the peak cell service capability has been reduced to $N/4$ and can no longer serve a local emergency need of $N/2$ or N somewhere in that cell. The peak capacity need must be provided for by provisioning all sites with the full complement of N channels of equipment, with attendant substantial cost increase.

However, this construct still does not provide for repeated communication to the entire coverage area. In order to accomplish this, an originating unlink communication from a portable in cell 1 on $F1$ will, in addition to being repeated in cell 1 on $F1'$, require repeating in the other three cells on $F2'$, $F3'$ and $F4'$. [Assuming each communication must include at least one other individual, the location of that other individual is unknown and thus all cells must be “lit up” simultaneously].¹¹ Cell site interconnections via whirling or point-to-point microwave will be required to complete the configuration. Assuming that all communications are one-to-one through repeaters, the same number of circuit connections, using 2 channels each, are required for a user set, independent of the number of cells. Thus, the number of system channels required is still N .

Thus, in this simplified consideration, additional spectrum is not required as the frequency band is varied. But system costs for the same coverage vary tremendously.

Analysis

The system cost function can be generalized by assuming that a shift in spectrum band results in a range reduction factor of L_f and a portable transmitter power reduction (due to EME requirements for instance) range reduction factor of L_p ¹². Further, it is observed that the more cells that are required, the lower the base antenna heights generally become. Thus, there is also an associated loss in range due to the lower antennas. Let this range reduction factor be L_a . Generally, a reduction in antenna height will follow a 6 dB/octave¹³ rule. As an approximation, it is assumed here that the average antenna height falls in proportion to the square root of the number of cells¹⁴. For

¹⁰ However, there may also be users arriving at the peak need site that are not in the normal class of system users (for which the “average” applies). This will often be the case in emergency situations e.g. the Oklahoma bombing where multi-service interoperability goals are pursued.

¹¹ More complex systems, with associated further increases in cost, might intelligently handle this requirement better.

¹² This factor would be determined by use of whatever propagation law slope is appropriate. For instance, assuming propagation loss is of a $L=35\log D$ nature or $D=10^{(L/35)}$, then a 6dB reduction in power would result in $D2=D1/[10^{(6/35)}]=D1/1.48=D1*0.67$. The range reduction factor is $R_p=0.67$.

¹³ 1/2 the height equals a 6dB increase in propagation loss.

¹⁴ It would be expected that this factor actually would become less significant as the number of cells became

instance, moving from 1 to 4 to 16 cells lowers average antenna heights by factors of 1, 1/2 and 1/4 respectively.

It can be shown then that the number of cells required, X, for an increase of operating frequency, is:

$$X \cdot 10^{-((40/Z)\log X^{0.5})} = 10^{((2/Z)(L_f + L_p))} \quad \{X \text{ is a complex solution}\}$$

where: Z is the propagation coefficient e.g. 35 for L=35logD
L_f is the net frequency shift loss factor in dB, considering antenna gain changes, propagation and building penetration loss changes, etc.¹⁵
L_p is the power reduction, dB, caused by EME requirements, FCC rules, etc.

It is generally well known that propagation coefficients for urban/suburban environments are between 30-40¹⁶; 35 is assumed here. L_p is assumed to be determined by EME limits, which generally decrease at a 6 dB/octave rate¹⁷ for the frequencies of issue here; thus L_p=20log(F₂/F₁), where F₁ is the reference frequency and F₂ is the new frequency under consideration, here being 850 MHz and 2300 MHz, respectively. L_f is assumed to be 5 dB, from extension of the PSWAC analysis, for these same frequencies. Total equipment costs will be approximately C*X, where C is the equipment cost for the reference single cell.

very large

¹⁵ Ref. PSWAC report, Spectrum/Technology.

¹⁶ Okumura/Hata at 2300MHz appear to be about 33.

¹⁷ All other things held constant, the EME limit will decrease in proportion to decreases in antenna effective area, which decreases proportional to frequency at a 6dB/octave rate.

Some specific examples of results are summarized in Table 1 below.

Table 1

Case	Freq Factor Lf (dB)	Pwr Factor Lp (dB)	Cells Req'd X	Equipment Cost factor
1	5	0	5	5
2	5	5	22	22
3	5	10	100	100
4	5	8.6	66	66
5	5	4.2	17	17

Case 1 represents the theoretical condition where portable transmitter power was allowed to be maintained at the same value at 2300 MHz as at 850 MHz. This still requires a cell count increase from 1 to 5.

Case 2 and 3 are arbitrary to demonstrate the rapid cell count and system cost increase with increases in Lp. It is seen that very large cell count and system cost (and complexity) increases result for this relatively limited Lp range.

Case 4 represents the actual Lp factor of 8.6 dB, determined from $L_p = 20 \log(2300/850)$. A very large increase in cell count and system cost results i.e. 66:1.

Case 4 indeed would represent the projected cell count/cost increase expected, in order to provide the same coverage, quality of communications and local area emergency peak communications capacity as the single reference cell. However, this assumes that the reference portable was using maximum power (again EME limited) at 850 MHz. An examination of what is actually predominant in use today shows that power levels are approximately 4.4 dB or more below the maximum allowed.¹⁸ Thus the 8.6 dB figure is 4.4 dB overstated and can be reduced to $8.6 - 4.4 = 4.2$ dB.

Case 5 then presents the results of this adjustment, resulting in a net projected cell count and system cost increase of 17:1 for 2300 MHz vs. 850 MHz.

CONCLUSIONS

Though it appears no additional spectrum is required as the operating frequency is increased, equipment costs and complexities increase substantially as more cells are required to service the same coverage area.


These equipment cost increases are substantially greater for Public Safety systems than for public type cellular telephone systems as the latter systems will normally assume a relatively constant peak to average load ratio as cells are split to smaller sizes, allowing reductions in per cell equipment provisions as compared to holding a constant peak communications capacity (N channels) for each cell, independent of size. Thus, Public Safety system costs tend to increase in direct proportion to the number of cells.

¹⁸ Handheld occupational use.

For a relatively wide-area Public Safety portable application, with in-building coverage, the overall increase in system cost for operation at 2300 MHz vs. 850 MHz is projected to be approximately 17:1, increasing in direct proportion to the requirement for a 17 cell system rather than the reference single cell system. The amount of required spectrum/channels is expected to remain unchanged at the higher frequency.

CERTIFICATE OF SERVICE

I, Tanya R. Mason, of Motorola Inc. do hereby certify that on this 4th day of December, 1996 a copy of the foregoing "Comments" was sent to each of the following by hand:


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